Reaction-Diffusion Processes as a Computational Paradigm

Thomas C. Henderson
Department of Computer Science
University of Utah
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1 Introduction

Turing introduced reaction diffusion systems (RD-systems) as a mechanism which made possible the differentiation of morphological structure[8]. We have shown how these systems can be used to provide an information network for smart sensor systems[1]. However, we propose here that reaction diffusion systems provide a more general computational model, and indeed, can be shown to include the Turing machine model (or recursive function theory, etc.).

Others have influenced the development models of intelligence or learning based on dissipative systems or far from equilibrium systems. Prigogine[7] sets forth three major theses related to our study:

- irreversible processes are real,
- they play a fundamental constructive role, and
- irreversibility is deeply rooted in dynamics.

In far from equilibrium systems, the input of mass or energy may be sufficient to create structure to dissipate that energy (a dissipative structure). E.g., boiling water creates convection cells which link function to fluctuations. A new molecular order appears that basically corresponds to a giant fluctuation stabilized by the exchange of energy with the outside world. This is the order characterized by the occurrence of what are called *dissipative structures*.

Prigogine goes on to describe living organisms as far from equilibrium objects separated by instabilities from the world of equilibrium and states that they are necessarily "large," macroscopic objects requiring a coherent state of matter in order to produce the complex biomolecules that make the perpetuation of life possible.

A *bifurcation* is a new solution at some critical value of a parameter, and Prigogine notes that Turing's paper provided an early study of bifurcation in chemical kinetics. In fact, Turing visited Prigogine and discussed these issues[6]. Finally, Prigogine asserts